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A NEW GENUS OF PARASITIC GASTROPODS.

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A number of gastropods are known, living parasitically upon the body of certain echinoderms, which retain the shell and typical internal organization so that their systematic position is readily established. On the other hand several endoparasitic species exist which have become so highly modified that they stand in much the same relation to the free-living forms as *Sacculina* to the typical cirripedes. Owing to the lack of any detailed information relating to their ontogenetic development the relationship of such forms is highly problematical. And furthermore it is difficult to accurately follow the stages of the phylogenetic metamorphosis which the body has undergone, and accordingly to establish the homologies of some of the principal organs. Schiemenz[1] in a very suggestive paper has attempted to construct a hypothetical animal connecting the least modified species like *Stylifer* on one hand with the highly degenerate types represented by *Entoconcha.* In several respects the animal here described resembles the hypothetical form and in a measure enables us to follow some of the changes which the more degenerate species have undergone.

My attention was attracted to this gastropod by my friend and colleague Dr. W. K. Fisher who discovered it in a species of starfish (*Brisinga evermanni* Fisher) taken by the U. S. F. C. Str. "Albatross" in the neighborhood of the Hawaiian Islands (sta. 3467) at a depth of 310 fathoms. It occupied the cœlomic cavity close to the base of one of the arms, producing a marked distention (Fig. 2, Pl. I.) of the body wall. The animal was un-

[1] P. Schiemenz, "Parasitische Schnecken-Kritische Referat," *Biol. Centralbl.*, Bd. 9.

attached and was put in communication with the exterior by a slit-like aperture 2 mm. long. The body is subglobular in form, distinctly bilateral, light yellow in color and measures 14 mm. by 11 mm. The external opening, communicating with the exterior through the aperture in the arm of the host, is in the mid line and is surrounded by prominent lips. These last named structures are covered with a firm cuticle produced into 16 pairs of interlocking teeth (Fig. 6, Pl. I.).

An examination of Fig. 1, Pl. I., will disclose the fact that the body proper, containing practically all the organs except the female reproductive gland, is overgrown by a great fold attached to the front end of the body, but elsewhere separated from it by a narrow slit-like space which communicates with the above mentioned fissure-like opening guarded by teeth. Anteriorly the ventral surface of the body is developed into a snout-like projection bearing the mouth opening and a small pair of tentacles (Fig. 1). More posteriorly the ventral surface, corresponding to the foot of free living forms, is somewhat flattened but lacks the usual high ciliated epithelium and gland cells. Still farther back the peculiar kidney forms the ventral surface behind which is the rectum borne on a papilla-like elevation. Some of these characters and others to be mentioned indicate distinctly gastropod relationships which have been retained in spite of parasitic habits.

The entire surface of the body is covered with a cuticular layer usually well developed on the ventral surface over the lobe-like projections shown in Fig. 8, Pl. I. In this last named region it becomes developed into numerous small papillæ each of which is penetrated by what is probably a nerve fiber (Fig. 7, Pl. I.). Within the animal the layer is much thinner and over the respiratory papillæ (p) and the adjacent regions is provided with numerous slender and apparently solid, hair-like processes.

The hypodermal layer consists of flattened cells, with large nuclei, separated at many points to allow muscle fibers to attach directly to the overlying cuticle. In addition there are many bipolar cells, one fiber passing distally into the above mentioned cuticular papillæ the other becoming lost in the subjacent tissue.

The mouth opening is situated upon the summit of a well-defined

proboscis which is concealed from view by a fold (not shown in figure) springing from its base. From the study of sections it is evident that this fold is of greater length than the proboscis and is not united along the median line posteriorly. Externally the fold is covered by a cuticular layer which is continuous over the proboscis and within the digestive tract itself as far as the radula. This last named organ is in a very rudimentary condition since it consists of but a single tooth (Fig. 5, Pl. I.) composed of some finely granular substance staining intensely in Delafield's hæmatoxylin. On each side of it are the openings of the salivary glands which are doubtless the homologue of the ventral pair in other molluscs.

The main portion of each salivary gland consists of a large sac located at the sides of the body proper as shown in Fig. 1, Pl. I. The component cells are highly vacuolated structures containing a faintly staining, granular secretion that is present also in the adjoining cavity. Ventrally, in close proximity to the outlet of this portion of the organ, the walls of the sac change abruptly in character and consist of more slender non-staining elements developed into low folds. Surrounding these cells are others of considerably greater height that form a papilla projecting into the cavity of the next division of the organ (Fig. 4, Pl. I.). This last named section is plain-walled and is composed of low columnar cells containing small quantities of a finely granular material, possibly a glandular substance differing from that of the larger sac. At the base of the proboscis the walls become produced into several small folds before entering the slender canal passing onward to its outlet at the side of the radula. Beyond the radula the pharyngeal or œsophageal epithelium becomes thicker and is attached to several muscle fibers acting as dilators and constrictors. The opening into the stomach is on the summit of a papilla whose general features are represented in text fig. A.

Opening into the œsophagus in close proximity to the stomach are two sets of glands, that may correspond to the dorsal salivary glands of other molluscs, whose position has shifted, though there is a possibility that they are strictly œsophageal products. Each group extends from the neighborhood of their outlet far

out into the pseudo-pallium, in some instances coming in contact with the hypodermal layer. So far as may be judged from the present specimen every cell possesses a slender ductule extending to its independent opening into the œsophagus. The secretion is colorless or of slightly pinkish tinge and in many cases is of less volume than the uniformly granular, strongly staining nuclei. In some instances the last named structures are more or less spherical, and again may be mammillated or formed of approximately eight globular masses as though formed by the incomplete fusion of as many chromosomes.

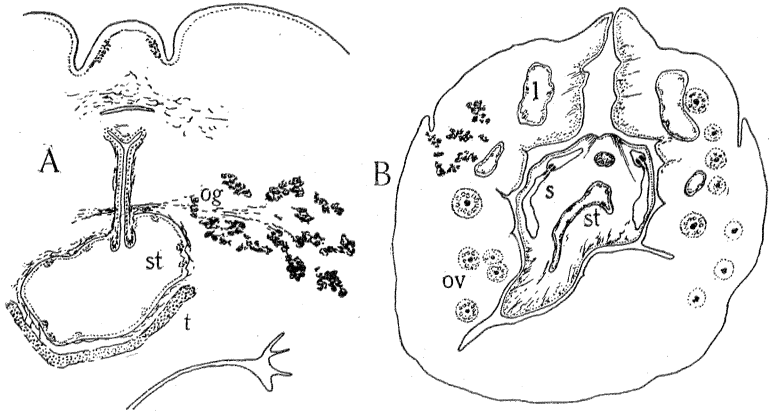


FIG. A. Section at level of œsophageal opening into stomach (*st*). *og*, œsophageal glands; *t*, testis.

FIG. B. Section corresponding to line *A*, Fig. 1, Pl. I. *l*, liver; *ov*, ova; *s*, salivary gland; *st*, stomach. The pleural pedal ganglion above (in figure) the stomach has, for the sake of clearness, been shifted slightly forward in Fig. 1, Pl. I.

The stomach is a voluminous sac extending throughout the greater part of the body proper. Its walls are composed of what appear to be two distinct types of cells (Fig. 3, Pl. I.) though they may possibly represent different stages of glandular activity. The more abundant form is almost cubical, highly vacuolated and contains a few slightly yellowish spherical granules. Among these are very much larger elements protruding some distance into the neighboring lumen and distended with a finely granular vacuolated material in which are a few spherical granules similar to those of the other type of cell. Opposite the level of the proboscis the stomach is expanded on each side to form a voluminous

pouch provided with a few secondary branches. These pouches probably are to be considered as representing the hepato-pancreas of other molluscs though the component cells differ in scarcely any essential respect from those of the main division of the stomach. At several points in the pseudo-pallium structures occur that strongly resemble the liver, but as they lack any definite connections it is impossible to claim that they were once united with the digestive tract.

The intestine presents the form of a cylindrical tube invested with numerous circular and longitudinal muscles attached by connective tissue and muscle bundles to the stomach and body wall. Its epithelial lining consists of relatively slender cells whose boundaries distally are difficult to determine owing to the large quantities of highly vacuolated protoplasm they contain. The outlet is guarded on each side by a large conical papilla covered with a thick cuticle fashioned near its tip into several slender filaments.

The stomach contains a small quantity only of a finely granular substance so that it is impossible to gain any insight into the methods of feeding and the nature of the food of this animal. It is probable that the proboscis and tentacles may be protruded through the external slit-like opening and organic substances may be picked up from the ooze as its host crawls about. It apparently absorbs little if any nourishment from its host though there may be some interchange of gases.

No sign of a heart exists in this species as is the case also with *Entoconcha*. A clotted substance abounds in the lacunæ among the various organs which doubtless represents blood. Groups of cells here and there may be corpuscles but their resemblance to connective tissue cells renders the determination uncertain.

As noted in a preceding paragraph respiration may be effected to a slight degree through the general body surface in contact with the cœlomic fluid of the host. The chief respiratory organs however appear to be the finger-shaped processes (Fig. 1, *p*, Pl. I.) attached to the posterior end of the body. With the exception of the hypodermal layer and a few muscle fibers passing in various directions from wall to wall or attached throughout their entire extent to the walls these organs are hollow and are probably

more or less distended with blood in a living condition. It is probable also that they may be extended into the neighborhood of the external opening or even protruded through it.

A problematic organ, which appears to be a kidney, is situated beneath the stomach anterior to the intestine (Fig. 1, *k*, Pl. I.). In this region the body wall is provided with a considerable number of outpouchings of varying size, though usually comparatively short, each of which is invested with a definite cuticular layer. In life all of these are probably filled with blood and are lined with a few connective tissue and muscle fibers some of which may span the cavity. With the exception of a few of the anterior projections the walls are provided internally with a very considerable number of relatively slender finger-shaped processes resembling those on the inner wall of certain prosobranch kidneys. They differ, however, in being invaginations of the body wall and are lined with a continuation of the cuticular layer covering the body generally. The cells of these minor processes are of moderate size, more or less cubical, though they often become flattened near the tip of the organ, and under high magnification have been seen in several instances to connect with a central lumen by means of delicate pores. Judging from these appearances the cells of each of these slender processes extract from the surrounding plasma waste materials, and pass them into the contained lumen from whence they make their way to the exterior.

While the ganglia are readily located the nerves are not sharply differentiated from the muscle fibers through which they pass and accordingly have been traced in a few cases only. The cerebral ganglia, united by a relatively long commissure, are situated in front of the pharynx and beneath the forward end of the stomach (Fig. 1, Pl. I.). Two connectives lead backward at the sides of the pharynx to the pleuro-pedal ganglionic masses placed about opposite the level of the posterior border of the proboscis. These last named ganglia are indistinguishably fused though they are distinctly paired and originate a very few small nerves that have been followed for a short distance only. One large branch on each side, arising from the anterior half of the nerve mass, passes dorsally and laterally and breaks up into three divisions. The first passes up into the large fold or pseudo-pallium close to the

large cavity, ventral to the body proper, that communicates with the exterior. The second pursues a course anteriorly in the pseudo-pallium and disappears from view among the large ova. The third, also in the pseudo-pallium, makes its way backward for a considerable distance but finally vanishes in several small muscle bundles.

Together with *Entoconcha* and *Enteroxenos* this species is monœcious and the ovary and testis are separate and distinct. The testis occupies a position lateral and ventral to the stomach about opposite the level of the pharynx, and is bilaterally symmetrical and gives evidence of being a paired organ. In the region concealed by the liver in Fig. 1. Pl. I., the organ is continuous across the mid line; but anterior to this point the unpaired division develops an extensive anteriorly directed pouch on each side of the stomach. The gland is in an immature condition, containing many spermatogonia but no later stages. Behind the unpaired section a duct of very large caliber arises, on each side of the mid line, with thin walls and a glandular, apparently ciliated, low ridge on its inner face. In this condition it continues to a point opposite the middle of the kidney where it contracts abruptly to a slender, thicker walled tube which is directed ventrally to open into the narrow slit-like space between the body and some of the kidney lobes.

The ovary is confined to the large fold enveloping the body, practically all of the space unoccupied by the liver being filled with large ova. These are suspended, almost precisely as in the chitons (see Haller's Fig. 328, Lang's "Lehrbuch," p. 366), in slender sacs, outpouchings of the germinal epithelium, and in a completed condition are surrounded by a follicle. No definite oviducts are present, the ova probably escaping by means of ruptures in the wall adjacent to the body proper.

The ova, fertilized either in or out of the body, may readily escape from the animal and from the host and doubtless in the free-swimming stage make their way to another host into which they burrow and take up their final position. The changes that ensue are wholly unknown but it is evident that the fold or pseudo-pallium, in this species at least, is not a portion of the foot. As may be seen in Fig. 1 it arises as a duplicature of the

body wall in front of the proboscis and may in reality represent a modified mantle, having been developed from such a type as now exists in the aspidobranchs.

Concerning the systematic relationships of this animal it is difficult to speak with certainty. From the paired character of the testis it appears to have been derived from some aspidobranch ancestor in which there were traces of the original bilateral symmetry. In its present condition the animal is perfectly symmetrical, but it does not follow that its immediate ancestors were such. Just as the modern more or less symmetrical lithodes have been derived from the asymmetrical hermit crabs so this species may have secondarily assumed its symmetrical condition.

The genus may be defined as follows:

Ctenosculum new genus. Body globular, bilaterally symmetrical, almost completely enveloped in a fold of the body wall. Proboscis and tentacles present. Two sets of salivary glands, radula reduced to one triangular tooth. Monœcious, testis and ovary distinct and separate, the latter occupying the fold. Parasitic in starfish, *Brisinga evermanni*, Hawaiian Ids. Type of genus *C. hawaiiense.*

C. hawaiiense new species. With characters of the genus.

Explanation of Plate I.

Fig. 1. *Ctenosculum hawaiiense* with left half of the pseudo-pallium removed. *c*, cerebral ganglia; *k*, kidney; *l*, liver; *o*, œsophagus; *p*, papillæ arising from body wall; *sg*, salivary gland; *st*, stomach.

Fig. 2. Cyst in starfish arm produced by parasite.

Fig. 3. Two types of cells of gastric epithelium.

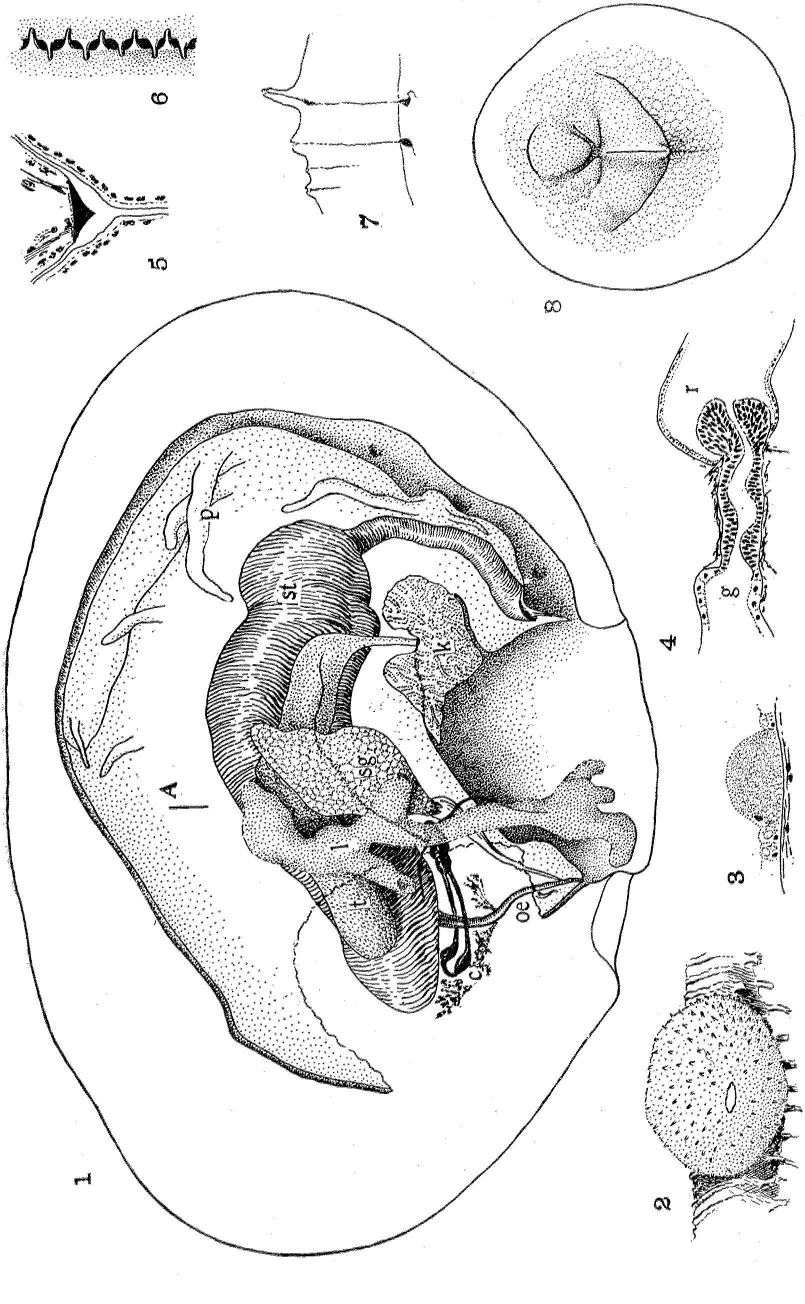
Fig. 4. Outlet of salivary gland (*g*) into reservoir (*r*).

Fig. 5. The single tooth of the radula with salivary ducts opening on each side.

Fig. 6. Cuticular teeth guarding the opening into space between body and pseudo-pallium.

Fig. 7. Papillate cuticle, from ventral surface of body, traversed by nerve fibers.

Fig. 8. *C. hawaiiense*, entire animal, ventral view.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